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PROPELLANT SURVEILLANCE REPORT LGM-30A, B, F AND G STAGE I TP-H--ETC(U)
DEC 77 J A THOMPSON

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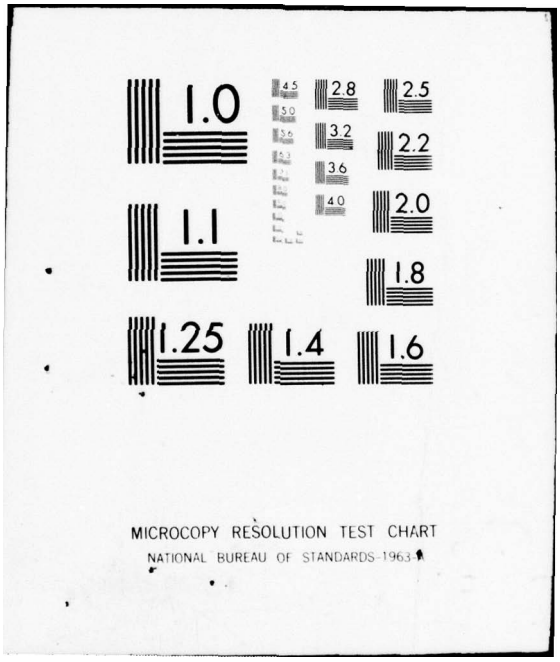
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1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

HEADQUARTERS

OGDEN AIR LOGISTICS CENTER

UNITED STATES AIR FORCE

HILL AIR FORCE BASE, UTAH 84406

PROPELLANT SURVEILLANCE REPORT LGM-30A, B, F&G STAGE 1 TP-H 1043

PROPELLANT LAB. SECTION

MANCP REPORT

NR 385(77)

DECEMBER 1977

MANCP REPORT NR 385(77)
MMWRM PROJECT M82937C and
M82938C

PROPELLANT SURVEILLANCE REPORT

LGM-30 A, B, F & G STAGE I

TP-H1043 AFT CLOSURE PROPELLANT

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December 1977

Industrial Products & Ldg Gear Division
Directorate of Maintenance
Ogden Air Logistics Center
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ABSTRACT

This report contains propellant test results from cartons of TP-H1043 propellant representing selected batches used in the aft closure of First Stage Minuteman Motors. Data from TP-H1043 propellant obtained from the aft closures of the LGM-30A, B, F and G Motors are reported in regression analyses for the fourth time and the third time using the G085 computer system. Testing was accomplished in accordance with MMWRME Project M82937C and M82938C.

An analysis of all parameters indicate that no significant degradation is anticipated for at least two years past the oldest data point.

Each point on the regression plot represents all samples at that particular age. The number of samples at each point is indicated on the sample size summary sheet on the page accompanying each regression plot. The data range at any age can be found by suitable inquiry of the G085 system.

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LIST OF REFERENCES

Report Nr	Title	Report Date
	LGM-30 First Stage, Wing I Test Reports	
29D	Zero Time Test Results (Aft Closure)	9 Jun 64
29E	Zero Time (Aft Closure Supplement 1)	24 Jun 64
32B	Zero Time, Wings II-V Test Results (Aft Closure)	18 Mar 65
185	ATP Phase I, Wing VI Series III	Jun 70
195	ATP Phase III, Wing II-V	Nov 70
239	Propellant Surveillance Report (TP-H1043)	Apr 72
288	Propellant Surveillance Report (TP-H1043)	Mar 74
337	Propellant Surveillance Report (TP-H1043)	Feb 76

GLOSSARY OF TERMS AND ABBREVIATIONS

Aging Trend	A change in properties or performance resulting from aging of material or component
CSA	Cross Sectional Area
DB	Dogbone
Degradation	Gradual deterioration of properties or performance
E	Modulus (psi), defined as stress divided by strain along the initial linear portion of the curve
EB	End Bonded
EGL	Effective Gage Length
em	Strain at maximum stress
er	Strain at rupture
"F" ratio	The ratio of the variance accounted for by the regression function to the random unexplained variance. The regression function having the most significant "F" ratio is used for plotting data. The ratio is also used in detecting significant changes in random variation between succeeding time points.
JANNAF	Joint Army, Navy, NASA, Air Force Committee
MAGCP	Propellant Lab Section at OOAMA
OOAMA	Ogden Air Materiel Area, Air Force Logistics Command
Regression Equation	The general form of the regression equation is $Y = a + bx$
Regression Line	Line representing mean test values with respect to time
S_b	Standard error of estimate of the regression coefficient
S_e or $S_{Y.X}$	Standard deviation of the data about the regression line

GLOSSARY OF TERMS AND ABBREVIATIONS (cont)

SM	Maximum Stress
Sr	Stress at rupture
Standard Deviation(S_n)	Square root of variance
Strain Rate	Crosshead speed divided by the EGL
"t" test	A statistical test used to detect significant differences between a measured parameter and an expected value of the parameter (determines if regression slope differs from zero at the 95% confidence level)
Variance	The sum of squares of deviations of the test results from the mean of the series after division by one less than the total number of test results
3 Sigma Band	The area between the upper and lower 3 sigma limit. It can be expected that 99.73% of the inventory represented by the test samples would fall within this range assuming that the population is normally distributed.
90-90 Band	It can be stated with 90% confidence that 90% of the inventory represented by the test samples would fall within this range assuming that the population is normally distributed.

SECTION I

INTRODUCTION

A. PURPOSE:

Quality assurance tests have been conducted for 10 1/2 years on First Stage LGM-30 TP-H1043 aft closure propellant.

Statistical analysis of the tests performed, as directed by Engineering, should provide early warning if serious degradation trends occur. Evaluation of the propellant provides data that can be put directly into engineering reliability and service life predictions. Testing was performed in accordance with MMWRME Directive GTD-1C, Amendments 1 and 2.

B. BACKGROUND:

TP-H1043 propellant is used in the aft closure of LGM-30A, B, F and G First Stage Motors.

This test period represents the fourth time that TP-H1043 propellant has been reported by regression analysis. This is also the third time that data has been processed utilizing the G085 system.

This report represents a large increase in the number of samples tested. Moreover, the age distribution increased to cover a 10 1/2 year time period (4 to 14 1/2 years).

The slope of the respective regressions for this report (Figures 1 thru 14) and the previous report (1976) are very close. This is the first time that the regression slopes of two successive test periods matched well. This is probably due to the increased number of samples and the stabilizing of post cure chemical changes in the binder.

C. SAMPLING PLAN:

As many as four aft closures are cast from the one TP-H1043 propellant mix. In order to reduce the number of tests, only one batch from each mix will be tested to obtain uniform test results. The selected batches are from the same batch as those previously tested and reported in MAGCP Reports 185(70), 195(70), 239(72), and 288(74).

Low rate tensile, high rate tensile and hardness tests were performed on each propellant batch mix.

D. STATISTICAL APPROACH:

Linear regression analysis was used as the method of data evaluation. Data from different time periods were used to establish a least squares trend line for the data. The variance about the regression line, obtained using individual values of the dependent variable, was used to compute a tolerance interval such that at the 90% confidence level, 90% of the sample distribution fall within this interval. This tolerance interval was extrapolated to a maximum of 24 months. The "t" values and the significance of this statistic, which are reported for each regression model, give an indication of the "statistical significance" of the slope of the trend line as compared to a line of zero slope.

Each point on the regression analysis is a calculation of all samples at that particular age. The number of samples at each point is indicated on the sample size summary sheet accompanying each regression plot. The data range at any age can be found by suitable inquiry of the G085 system.

SECTION II

TEST RESULTS

A. LOW RATE TENSILE:

All of the low rate test parameters show a statistically significant decrease (Figures 1 thru 5). The strain regressions (Figures 1 and 3) show a very gradual decrease. Regression slopes for stresses and modulus (Figures 2, 4 and 5) show a change with respect to time. This change is less than in the previous report. Although all of the regression trends show a decrease, the propellant still shows good stability and from this analysis the propellant will perform satisfactorily for at least two years beyond the last data point.

B. HIGH RATE TENSILE:

The strain and stress regressions show a statistically significant decrease with the modulus showing a statistically significant increase (Figures 6 thru 10). For all of the regressions, the slopes are gradual.

C. HARDNESS:

Shore A and C initial hardness test data regressions show a statistically significant gradual decrease and the 10 second test data regression shows no significant change.

SECTION III

CONCLUSIONS AND RECOMMENDATIONS

The slopes of the regressions are gradual and closer to a line of zero slope than in the previous report. From this analysis, no significant degradation seems likely and the propellant service life may be extended for at least two years from the date of last testing.

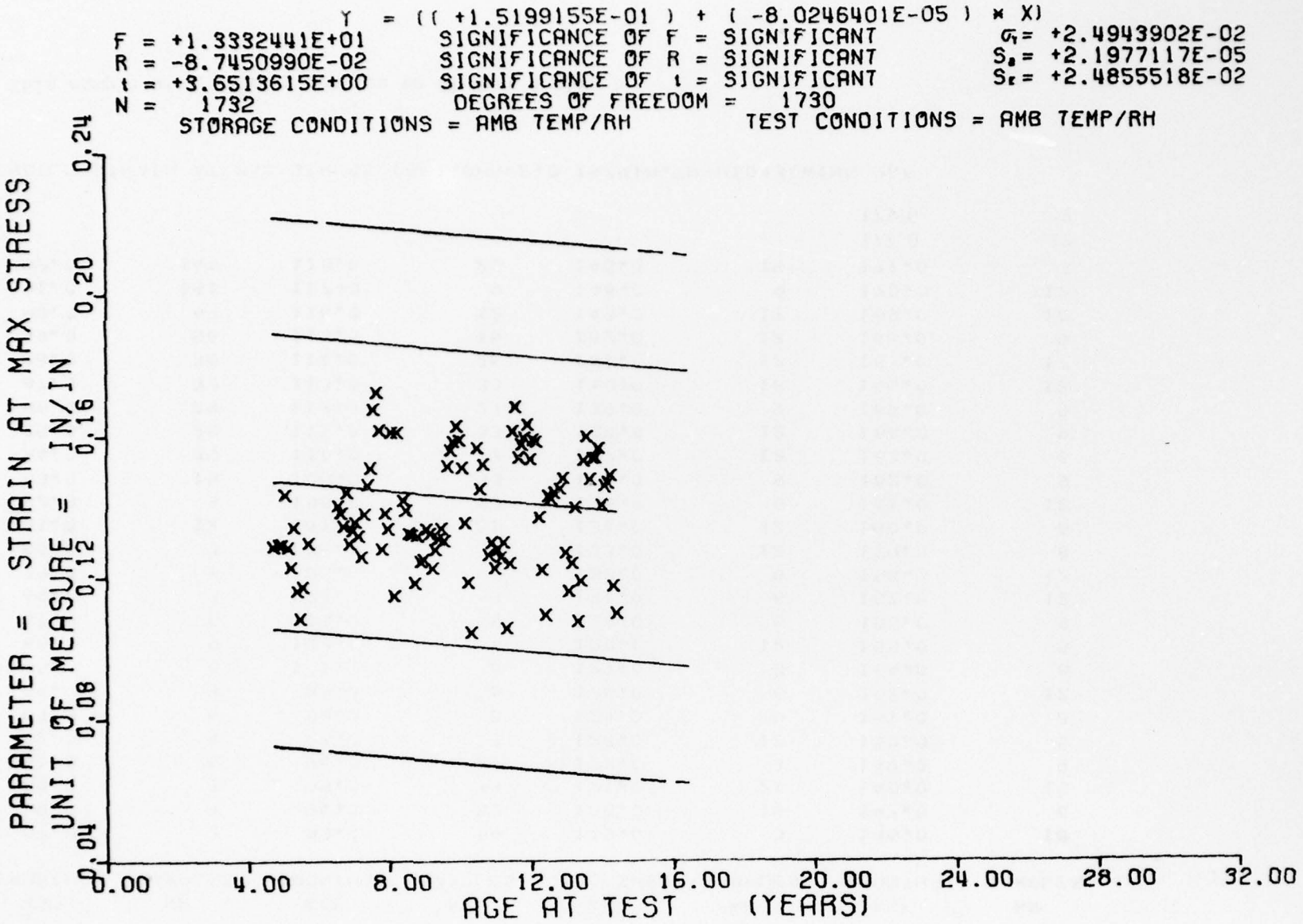
It is recommended that testing be continued to assure service life extension and confirm the present trend.

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
57.0	3	93.0	54	119.0	3	146.0	18
59.0	9	94.0	83	120.0	15	147.0	6
60.0	3	95.0	33	121.0	21	148.0	15
61.0	6	96.0	27	122.0	3	149.0	9
62.0	9	97.0	3	123.0	12	150.0	5
63.0	6	98.0	3	124.0	9	151.0	3
64.0	3	99.0	6	126.0	6	152.0	12
65.0	6	101.0	6	127.0	3	154.0	6
66.0	9	102.0	9	128.0	12	155.0	5
67.0	6	103.0	9	130.0	6	156.0	9
69.0	3	104.0	3	131.0	6	157.0	12
79.0	5	105.0	6	132.0	9	158.0	12
80.0	3	106.0	6	133.0	12	159.0	8
81.0	12	107.0	21	134.0	12	160.0	6
82.0	9	108.0	33	135.0	6	161.0	12
83.0	15	109.0	33	136.0	9	162.0	9
84.0	39	110.0	27	137.0	12	163.0	6
85.0	28	111.0	33	138.0	12	164.0	9
86.0	29	112.0	27	139.0	9	165.0	9
87.0	33	113.0	33	140.0	12	166.0	12
88.0	30	114.0	26	141.0	12	167.0	17
89.0	56	115.0	15	142.0	12	168.0	9
90.0	67	116.0	12	143.0	17	169.0	10
91.0	151	117.0	9	144.0	9	170.0	12
92.0	144	118.0	23	145.0	15	171.0	3
						172.0	12
						173.0	9

TENSILE STRAIN AT MAX STRESS (EM),CHS=2.0 IN/MIN,TP-H1043,WING 2&6

This sample size summary applies to Figures 1 thru 5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R = -8.7450990E-02 SIGNIFICANCE OF R = SIGNIFICANT
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PARAMETER = STRAIN AT MAX STRESS
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0.08
0.12
0.16
0.20
0.24
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
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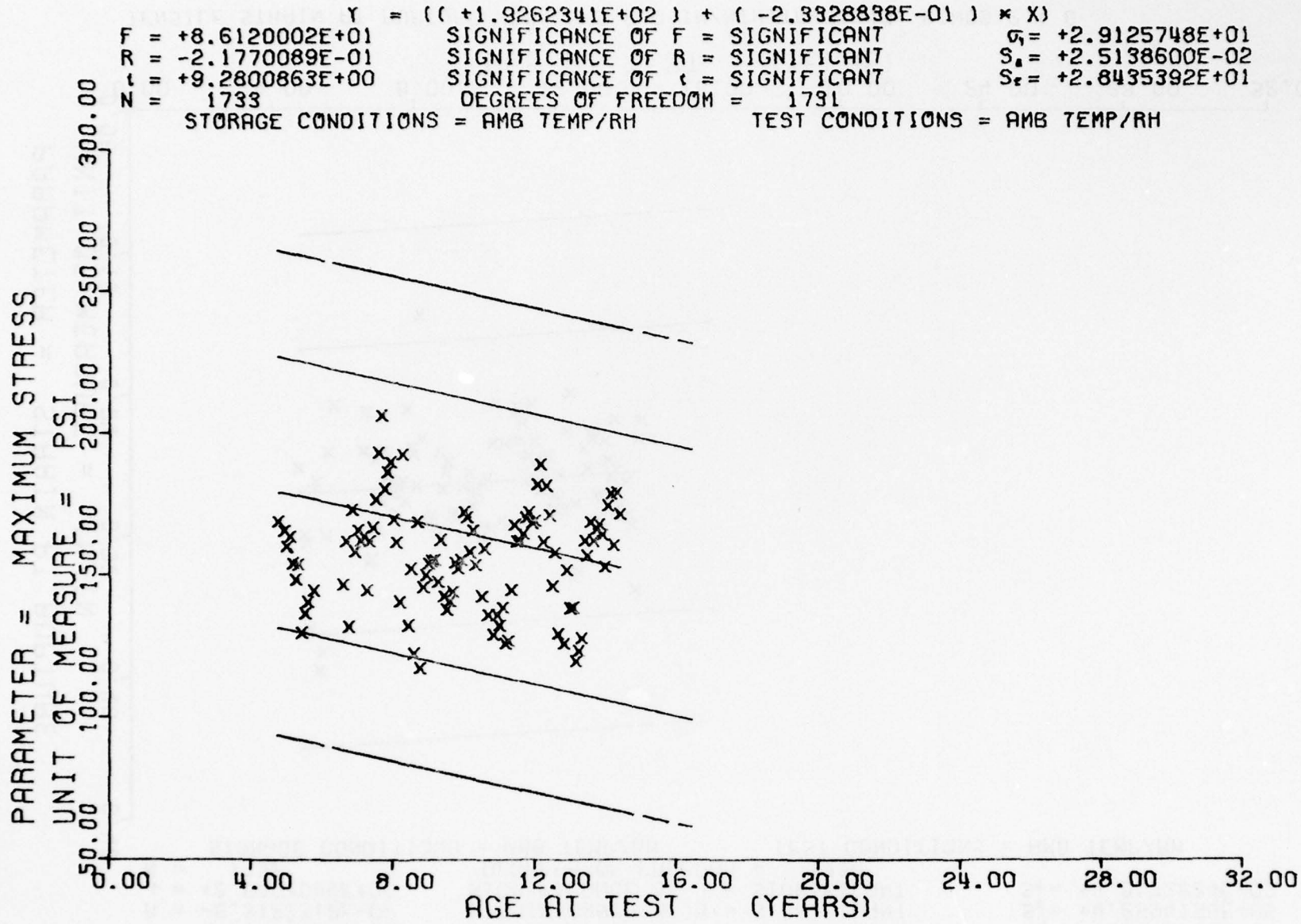
AGE AT TEST (YEARS)
TENSILE STRAIN AT MAX STRESS (EM),CHS=2.0 IN/MIN,TP-H1043,WING 2&6

Figure 1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R = -2.1770089E-01 SIGNIFICANCE OF R = SIGNIFICANT Sa = +2.5138600E-02
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PARAMETER = MAXIMUM STRESS
UNIT OF MEASURE = PSI
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250.00
200.00
150.00
100.00
50.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TENSILE MAXIMUM STRESS,CHS=2.0 IN/MIN,TP-H1043, WINGS 2 & 6

Figure 2

Y = ((+3.0261188E-01) + (-1.1205284E-04) * X)

F = +6.9206323E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_t = +4.8255138E-02

R = -6.3122312E-02 SIGNIFICANCE OF R = SIGNIFICANT S_a = +4.2594155E-05

t = +2.6307094E+00 SIGNIFICANCE OF t = SIGNIFICANT S_ε = +4.8172824E-02

N = 1732 DEGREES OF FREEDOM = 1730

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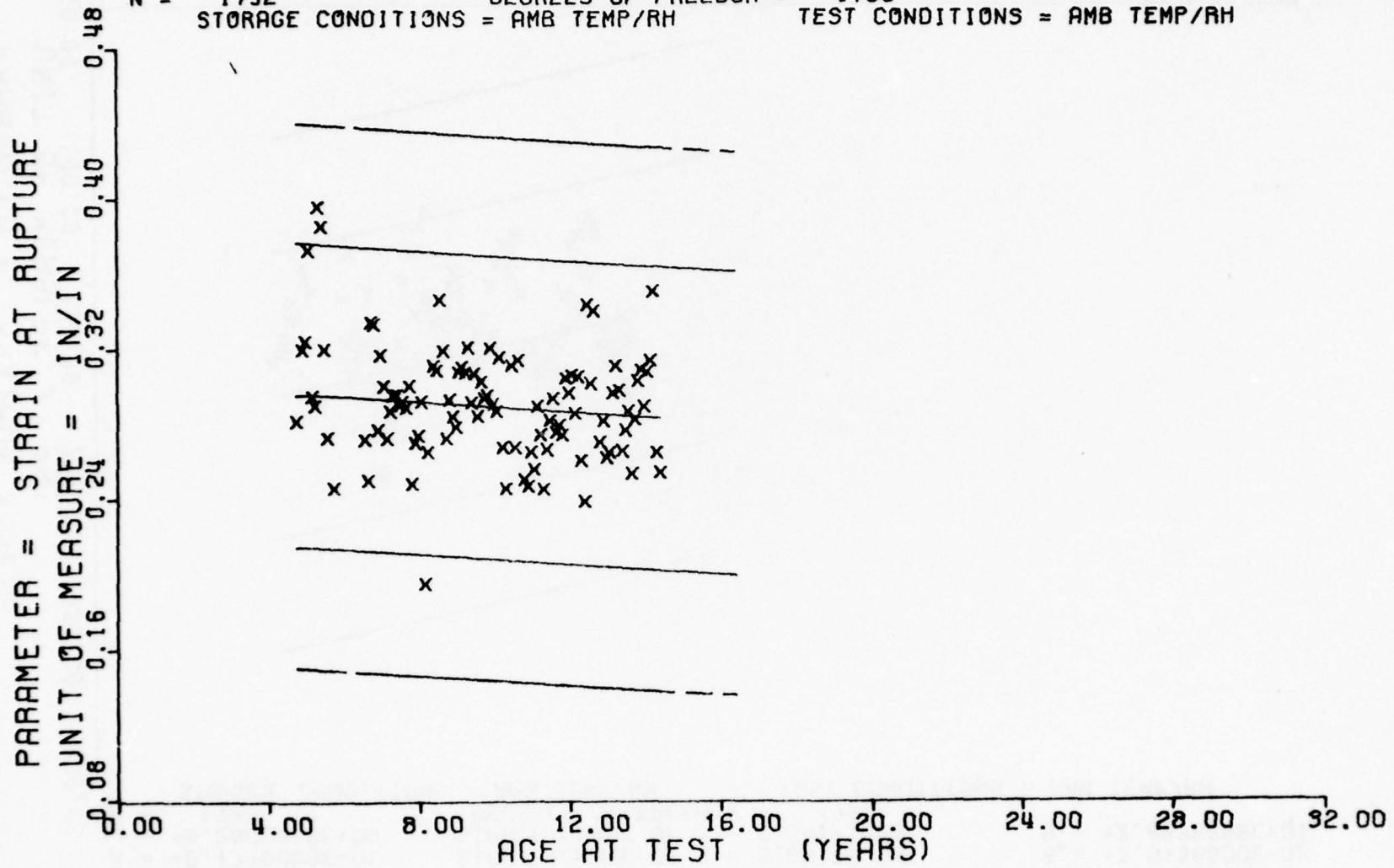
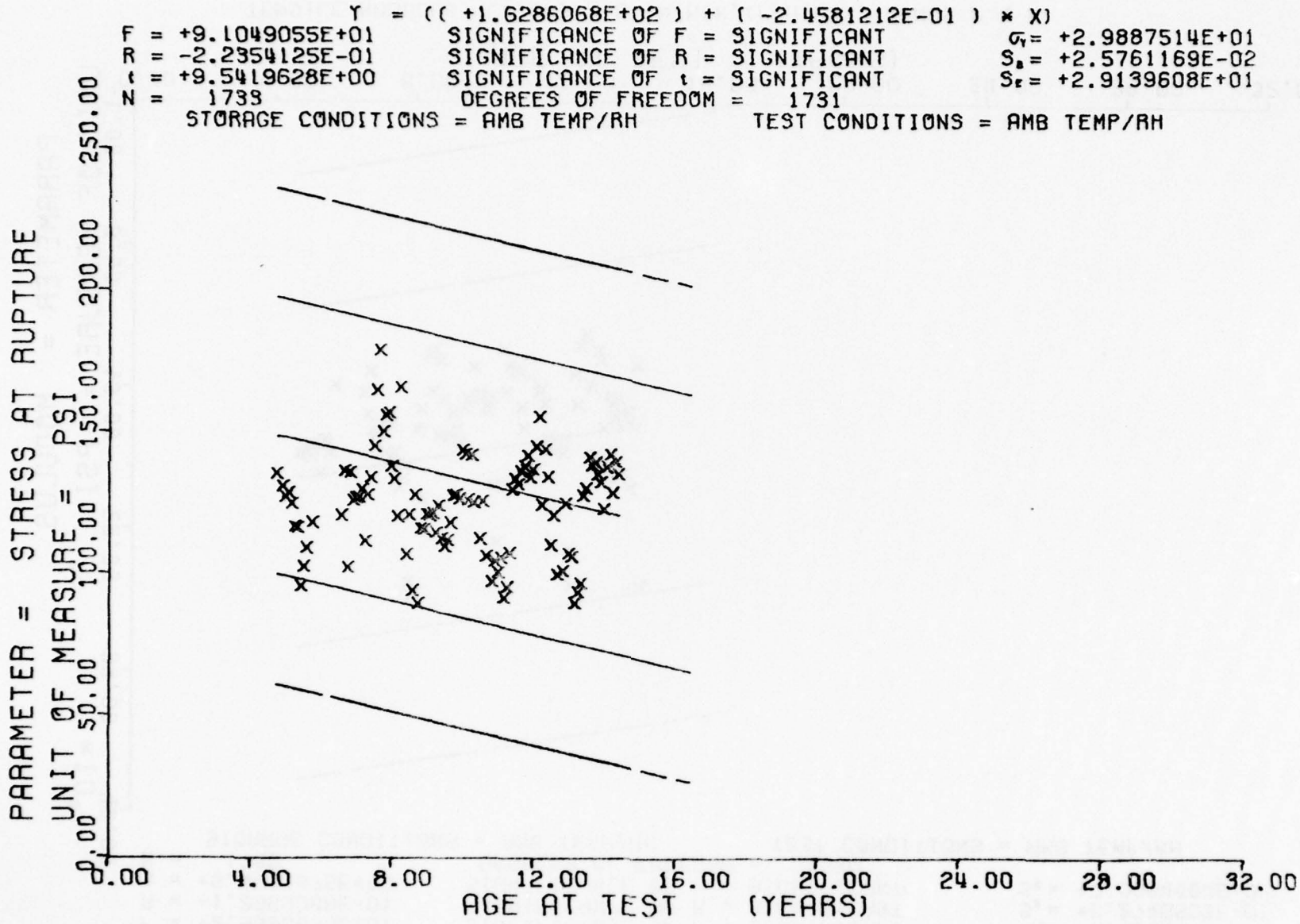


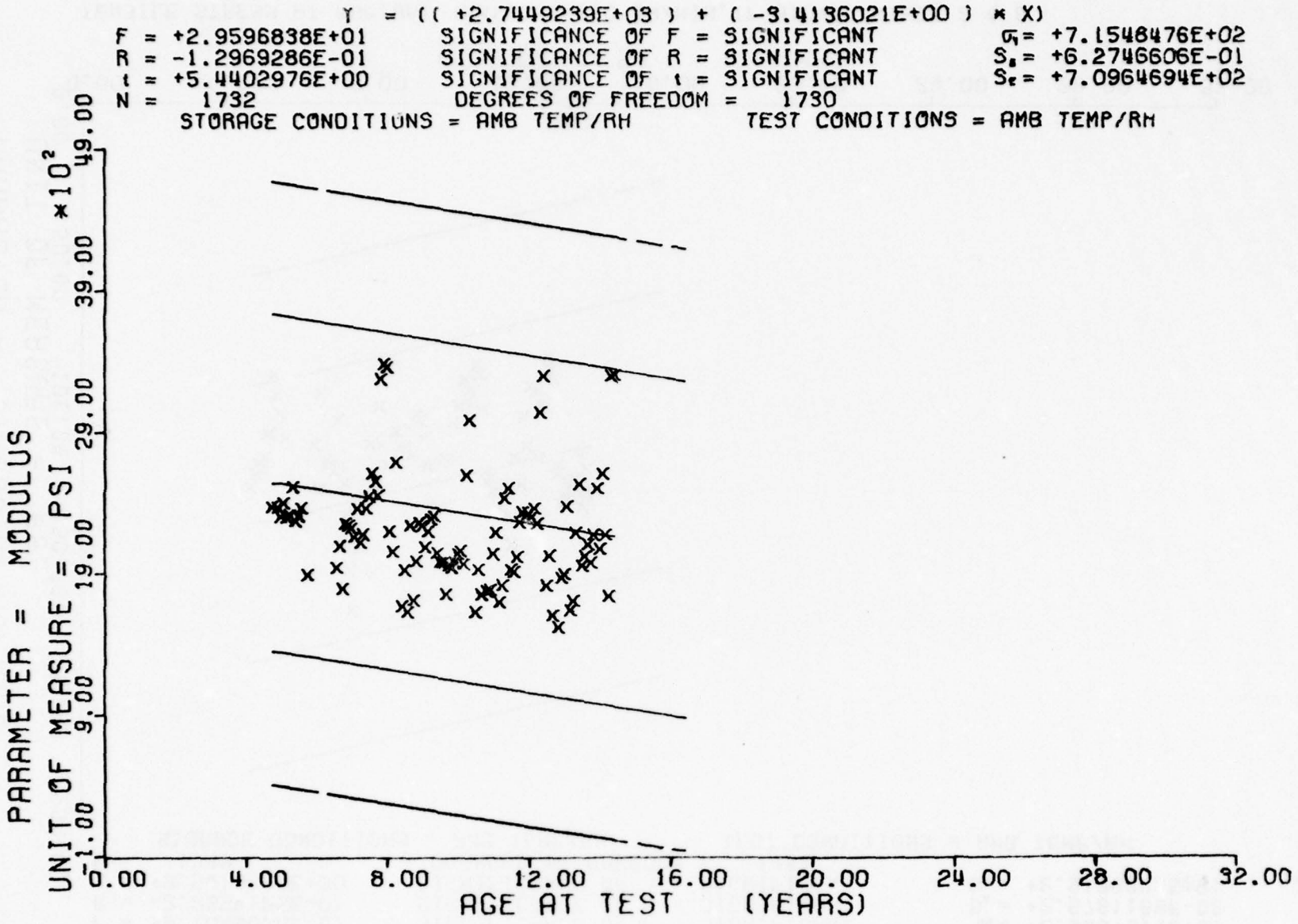
TENSILE STRAIN AT RUPTURE (ER), CHS=2.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 3



TENSILE STRESS AT RUPTURE (SR), CHS=2.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 4



TENSILE MODULUS (E), CHS=2.0 IN/MIN, TP-H1043, WINGS 2 & 6

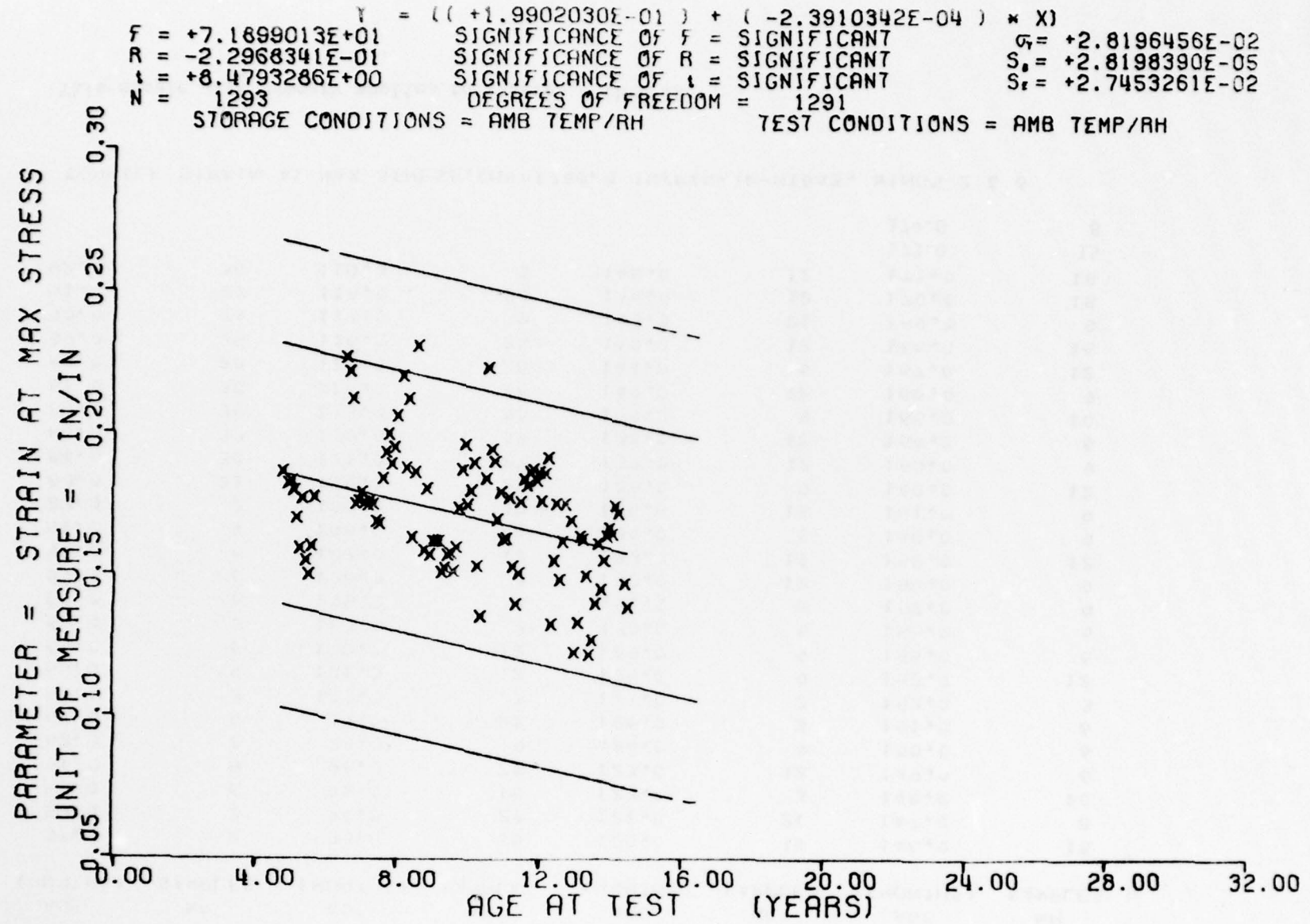
Figure 5

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
57.0	2	93.0	15	120.0	15	146.0	15
59.0	3	94.0	27	121.0	21	147.0	8
60.0	6	95.0	15	122.0	3	148.0	10
61.0	9	96.0	24	123.0	12	149.0	6
62.0	6	98.0	9	124.0	9	150.0	6
63.0	9	99.0	21	126.0	3	151.0	6
64.0	3	100.0	3	127.0	3	152.0	3
65.0	9	101.0	12	128.0	9	153.0	12
66.0	6	102.0	12	129.0	9	155.0	6
67.0	3	103.0	3	130.0	6	156.0	6
68.0	6	105.0	5	131.0	3	157.0	9
79.0	6	106.0	3	132.0	12	158.0	9
80.0	6	107.0	12	133.0	11	159.0	12
81.0	9	108.0	24	134.0	6	160.0	9
82.0	3	109.0	32	135.0	15	161.0	9
83.0	21	110.0	29	136.0	9	162.0	12
84.0	30	111.0	27	137.0	12	163.0	9
85.0	33	112.0	33	138.0	12	164.0	6
86.0	30	113.0	30	139.0	9	165.0	10
87.0	30	114.0	28	140.0	12	166.0	9
88.0	28	115.0	28	141.0	6	167.0	12
89.0	29	116.0	24	142.0	12	168.0	18
90.0	34	117.0	9	143.0	21	169.0	9
91.0	37	118.0	23	144.0	12	170.0	15
92.0	39	119.0	3	145.0	12	171.0	18
						173.0	15
						174.0	8

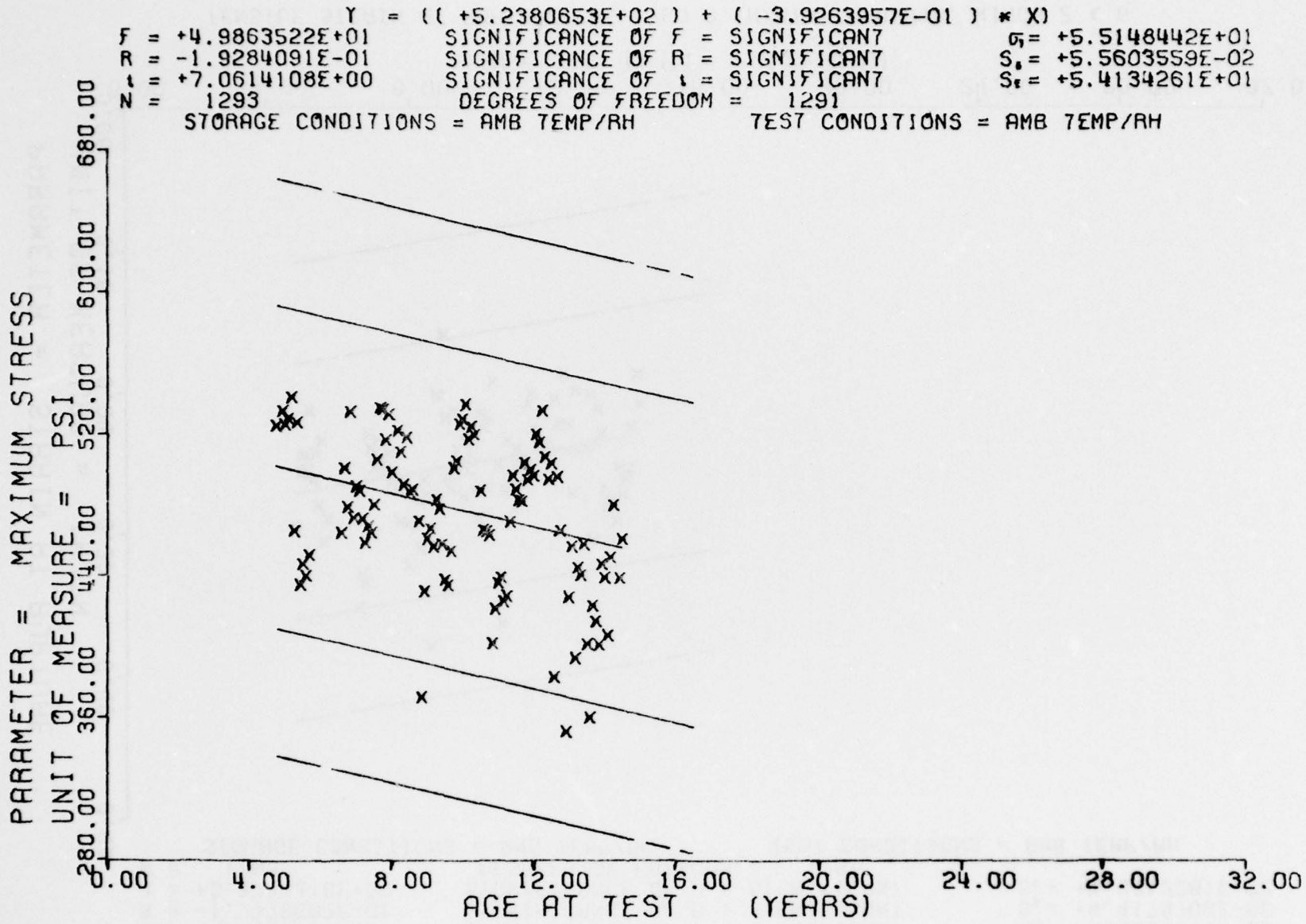
TENSILE STRAIN AT MAX STRESS, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

This sample size summary applies to figures 6 thru 10



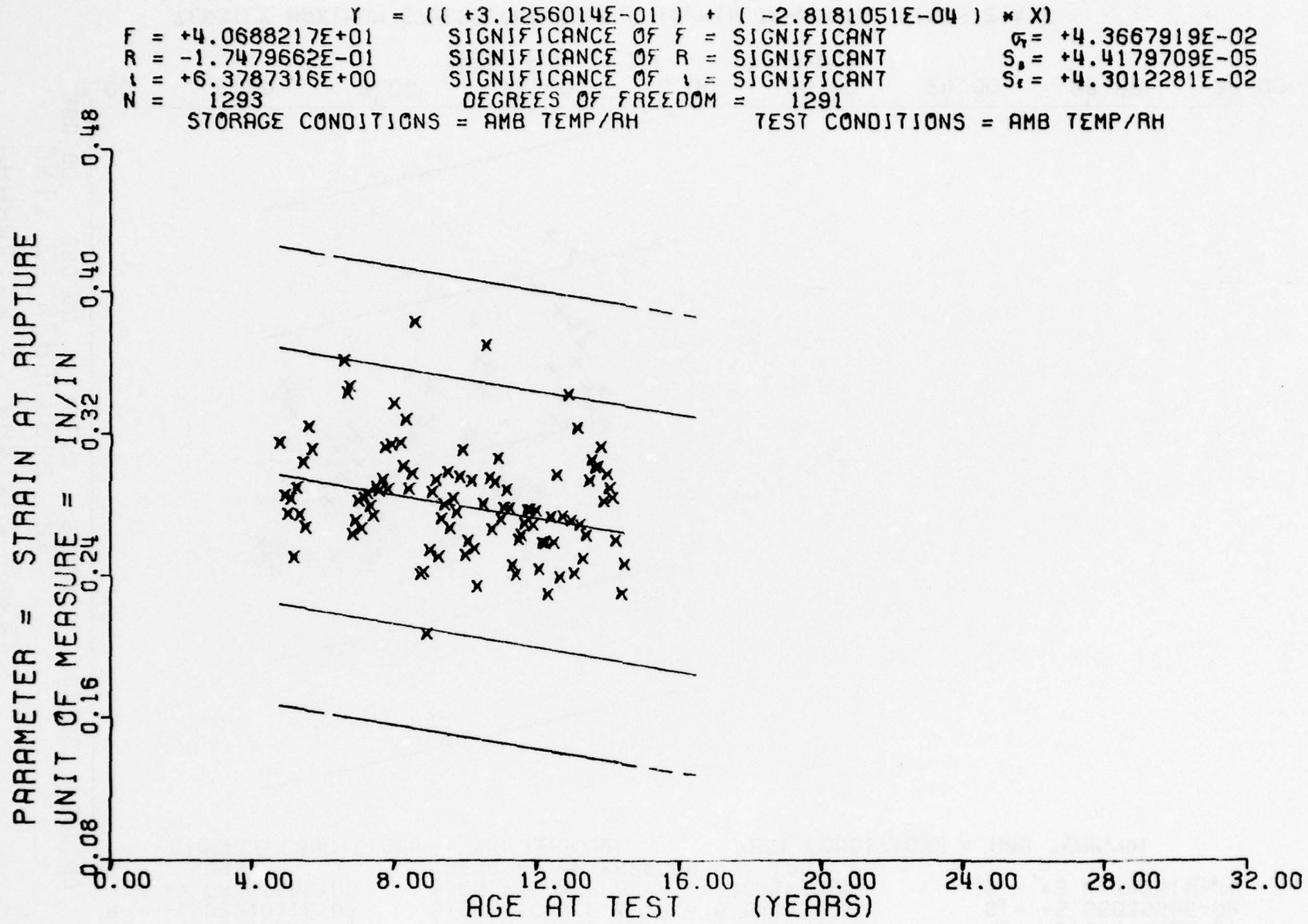
TENSILE STRAIN AT MAX STRESS, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 6



TENSILE MAXIMUM STRESS, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 7


Y = ((+3.1256014E-01) + (-2.8181051E-04) * X)
F = +4.0688217E+01 SIGNIFICANCE OF F = SIGNIFICANT σ = +4.3667919E-02
R = -1.7479662E-01 SIGNIFICANCE OF R = SIGNIFICANT S_a = +4.4179709E-05
t = +6.3787316E+00 SIGNIFICANCE OF t = SIGNIFICANT S_t = +4.3012281E-02
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STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT RUPTURE
UNIT OF MEASURE = IN/IN
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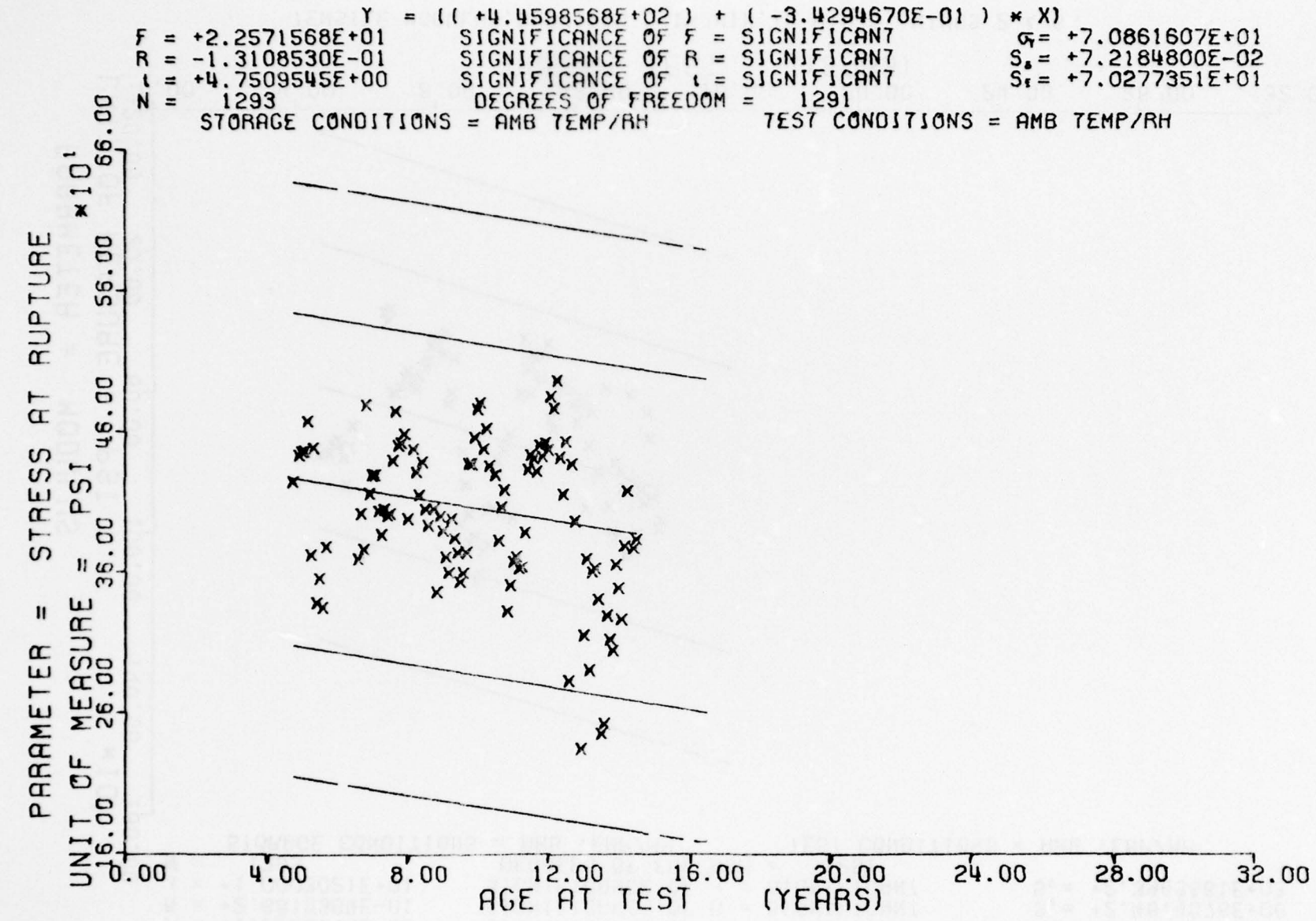
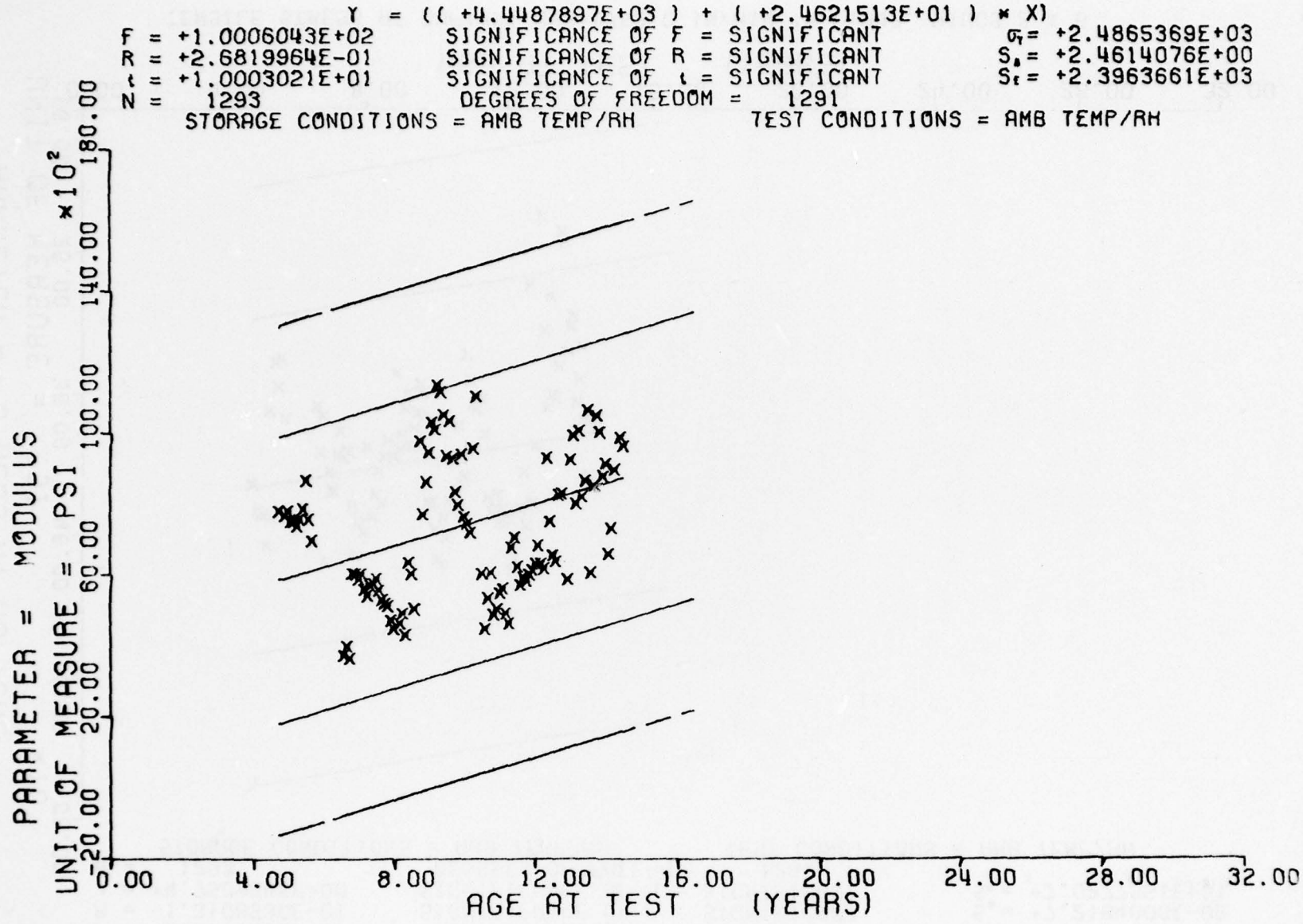
0.40
0.32
0.24
0.16
0.08
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TENSILE STRAIN AT RUPTURE, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 8



TENSILE STRESS AT RUPTURE, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 9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R = +2.6819964E-01 SIGNIFICANCE OF R = SIGNIFICANT S = +2.4614076E+00
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PARAMETER = MODULUS
UNIT OF MEASURE = PSI
*10²
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100.00
60.00
20.00
-20.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TENSILE MODULUS, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

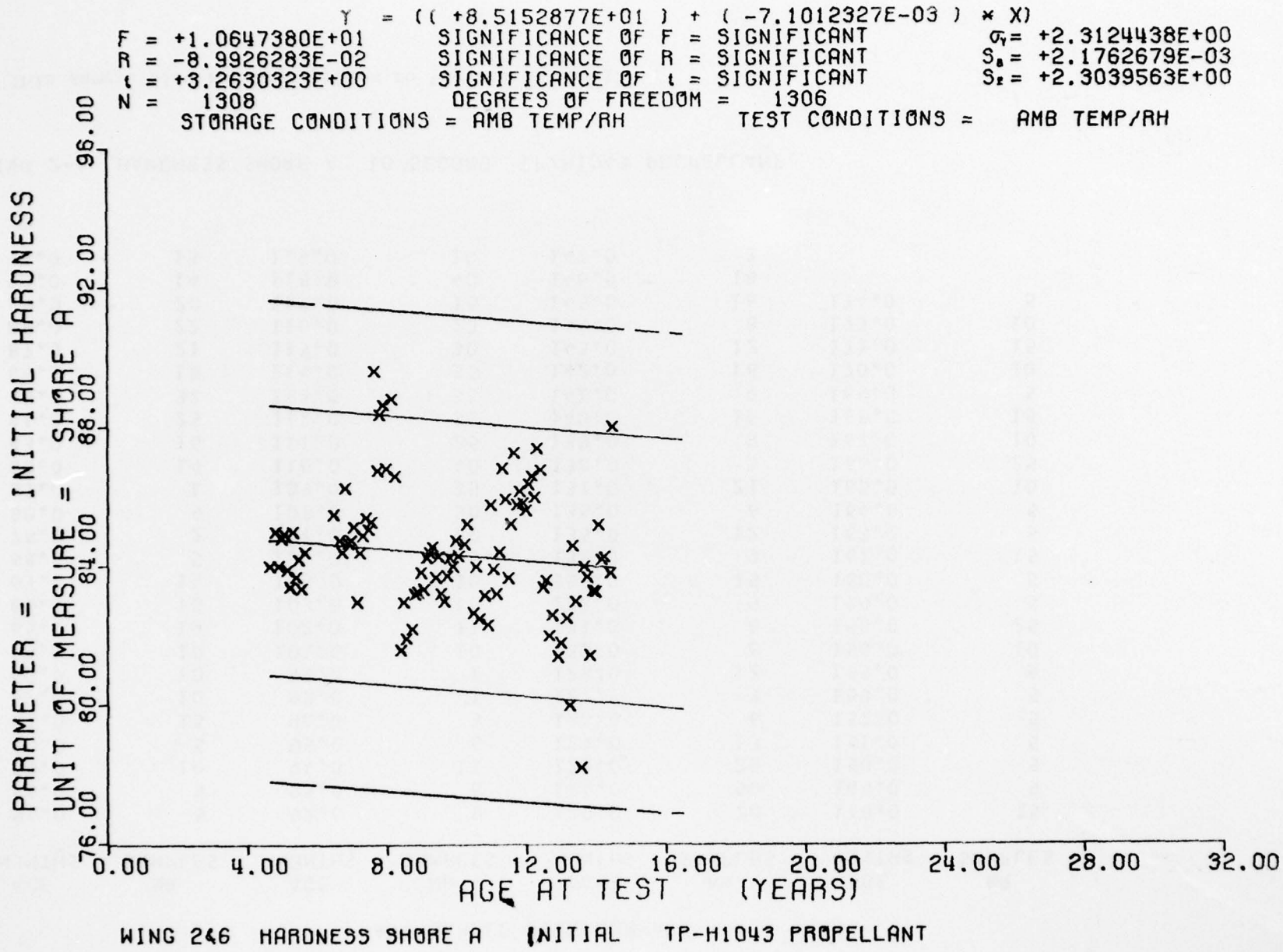
Figure 10

*** SAMPLE SIZE SUMMARY ***

AGE MONTHS	NR SAMPLES	AGE MONTHS	NR SAMPLES	AGE MONTHS	NR SAMPLES	AGE MONTHS	NR SAMPLES
56.0	5	92.0	9	120.0	20	148.0	15
58.0	5	93.0	6	121.0	40	149.0	9
59.0	10	94.0	11	123.0	20	150.0	5
60.0	5	95.0	6	124.0	13	151.0	5
61.0	15	96.0	3	126.0	6	152.0	5
62.0	10	98.0	1	127.0	3	153.0	5
63.0	10	99.0	1	128.0	12	155.0	5
64.0	10	101.0	10	130.0	6	156.0	10
65.0	10	102.0	11	131.0	6	158.0	25
66.0	10	103.0	15	132.0	9	159.0	5
67.0	11	105.0	10	133.0	15	160.0	5
68.0	5	106.0	5	134.0	9	161.0	15
78.0	2	107.0	20	135.0	12	163.0	5
80.0	4	108.0	30	136.0	6	164.0	5
81.0	1	109.0	35	137.0	21	165.0	10
82.0	14	110.0	40	138.0	3	166.0	25
83.0	16	111.0	25	139.0	9	167.0	10
84.0	25	112.0	35	140.0	15	168.0	15
85.0	32	113.0	35	141.0	9	169.0	5
86.0	19	114.0	35	142.0	18	170.0	10
87.0	21	115.0	30	143.0	12	171.0	15
88.0	22	116.0	20	144.0	8	173.0	10
89.0	28	117.0	15	145.0	16	174.0	5
90.0	14	118.0	40	146.0	18		
91.0	13	119.0	10	147.0	3		

WING 2-6 HARDNESS SHORE A 10 SECOND TP/H1043 PROPELLANT

This sample size summary applies to Figures 11 and 12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F = +1.0647380E+01 SIGNIFICANCE OF F = SIGNIFICANT σY = +2.3124438E+00
R = -8.9926283E-02 SIGNIFICANCE OF R = SIGNIFICANT Sa = +2.1762679E-03
t = +3.2630323E+00 SIGNIFICANCE OF t = SIGNIFICANT Sx = +2.3039563E+00
N = 1308 DEGREES OF FREEDOM = 1306
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = INITIAL HARDNESS
UNIT OF MEASURE = SHORE A
96.00
92.00
88.00
84.00
80.00
76.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
WING 246 HARDNESS SHORE A INITIAL TP-H1043 PROPELLANT

Figure 11

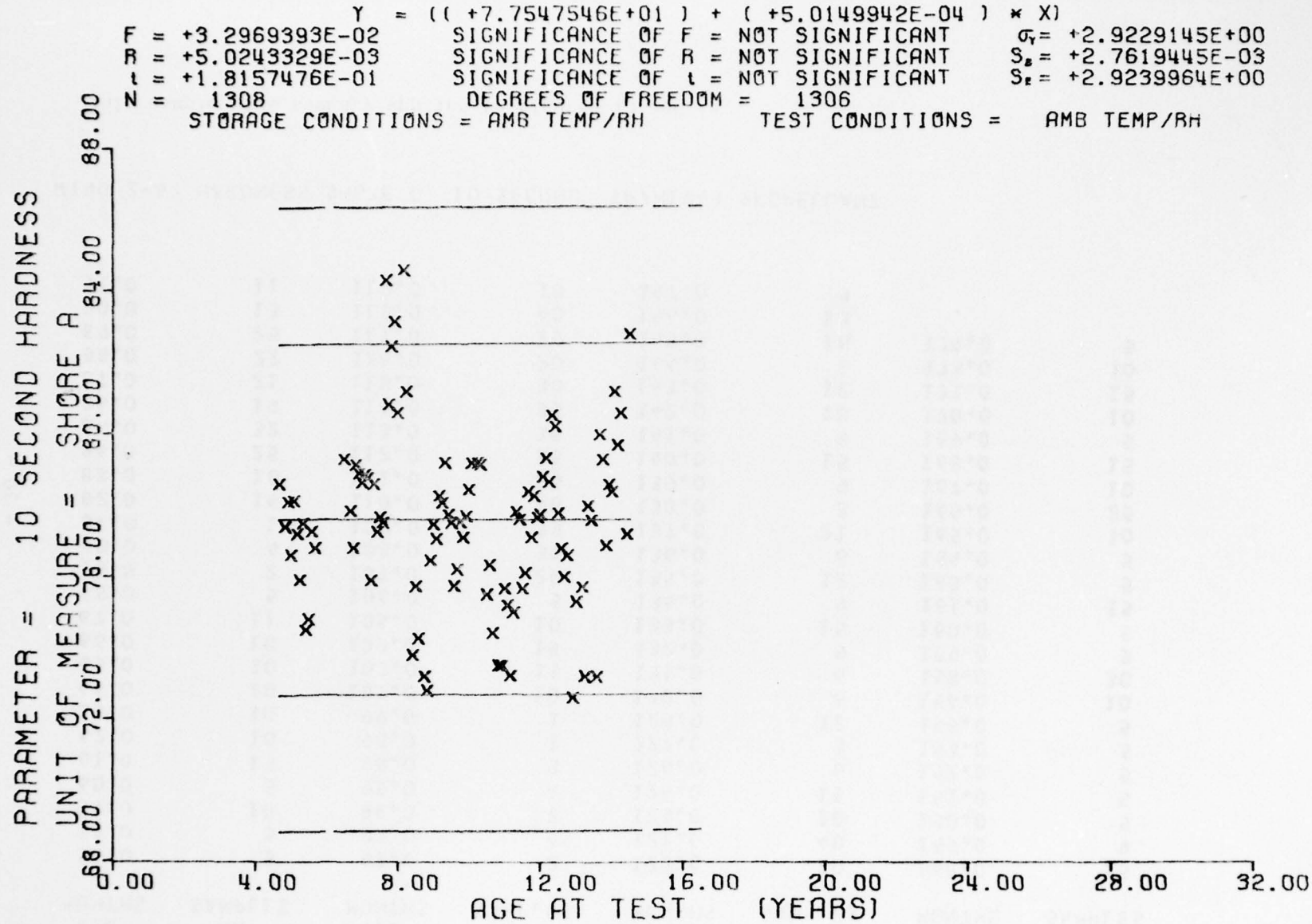
Y = ((+7.7547546E+01) + (+5.0149942E-04) * X)
F = +3.2969393E-02 SIGNIFICANCE OF F = NOT SIGNIFICANT σY = +2.9229145E+00
R = +5.0243329E-03 SIGNIFICANCE OF R = NOT SIGNIFICANT Sb = +2.7619445E-03
t = +1.8157476E-01 SIGNIFICANCE OF t = NOT SIGNIFICANT Se = +2.9239964E+00
N = 1308 DEGREES OF FREEDOM = 1306
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = 10 SECOND HARDNESS
UNIT OF MEASURE = SHORE A
88.00
84.00
80.00
76.00
72.00
68.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
WING 246 HARDNESS SHORE A 10 SECOND TP-H1043 PROPELLANT

Figure 12

*** SAMPLE SIZE SUMMARY ***

AGE MONTHS	NR SAMPLES	AGE MONTHS	NR SAMPLES	AGE MONTHS	NR SAMPLES	AGE MONTHS	NR SAMPLES
56.0	5	92.0	2	120.0	20	148.0	15
58.0	5	93.0	4	121.0	40	149.0	9
59.0	10	94.0	7	123.0	20	150.0	5
60.0	5	95.0	4	124.0	15	151.0	5
61.0	15	96.0	3	126.0	6	152.0	5
62.0	10	98.0	1	127.0	3	153.0	5
63.0	10	99.0	1	128.0	12	155.0	5
64.0	10	101.0	10	130.0	6	156.0	10
65.0	10	102.0	11	131.0	6	158.0	30
66.0	10	103.0	15	132.0	9	159.0	5
67.0	11	105.0	10	133.0	15	160.0	5
68.0	5	106.0	5	134.0	9	161.0	15
78.0	2	107.0	20	135.0	12	163.0	5
80.0	4	108.0	30	136.0	6	164.0	5
81.0	1	109.0	35	137.0	21	165.0	10
82.0	14	110.0	40	138.0	3	166.0	25
83.0	16	111.0	25	139.0	9	167.0	10
84.0	25	112.0	35	140.0	15	168.0	15
85.0	32	113.0	35	141.0	9	169.0	5
86.0	19	114.0	35	142.0	18	170.0	10
87.0	21	115.0	30	143.0	12	171.0	15
88.0	22	116.0	20	144.0	8	173.0	10
89.0	25	117.0	15	145.0	16	174.0	5
90.0	13	118.0	40	146.0	18		
91.0	11	119.0	10	147.0	3		

WING 2-6 HARDNESS SHORE C 10 SECOND TP/H1043 PROPELLANT

This sample size summary applies to Figures 13 and 14

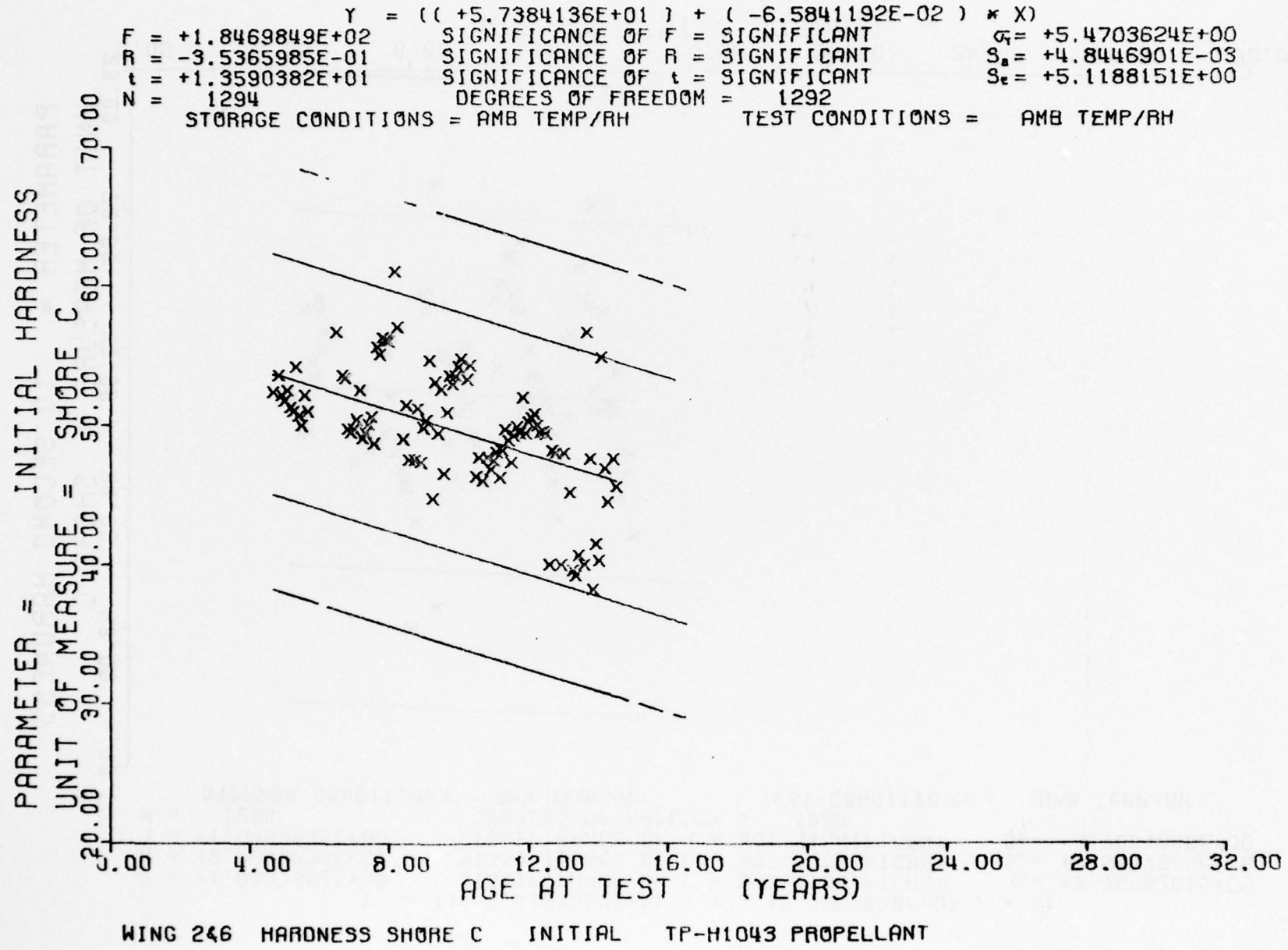
Y = ((+5.7384136E+01) + (-6.5841192E-02) * X)
F = +1.8469849E+02 SIGNIFICANCE OF F = SIGNIFICANT σ = +5.4703624E+00
R = -3.5365985E-01 SIGNIFICANCE OF R = SIGNIFICANT S = +4.8446901E-03
t = +1.3590382E+01 SIGNIFICANCE OF t = SIGNIFICANT S = +5.1188151E+00
N = 1294 DEGREES OF FREEDOM = 1292
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = INITIAL HARDNESS
UNIT OF MEASURE = SHORE C
70.00
60.00
50.00
40.00
30.00
20.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
WING 246 HARDNESS SHORE C INITIAL TP-H1043 PROPELLANT

Figure 13

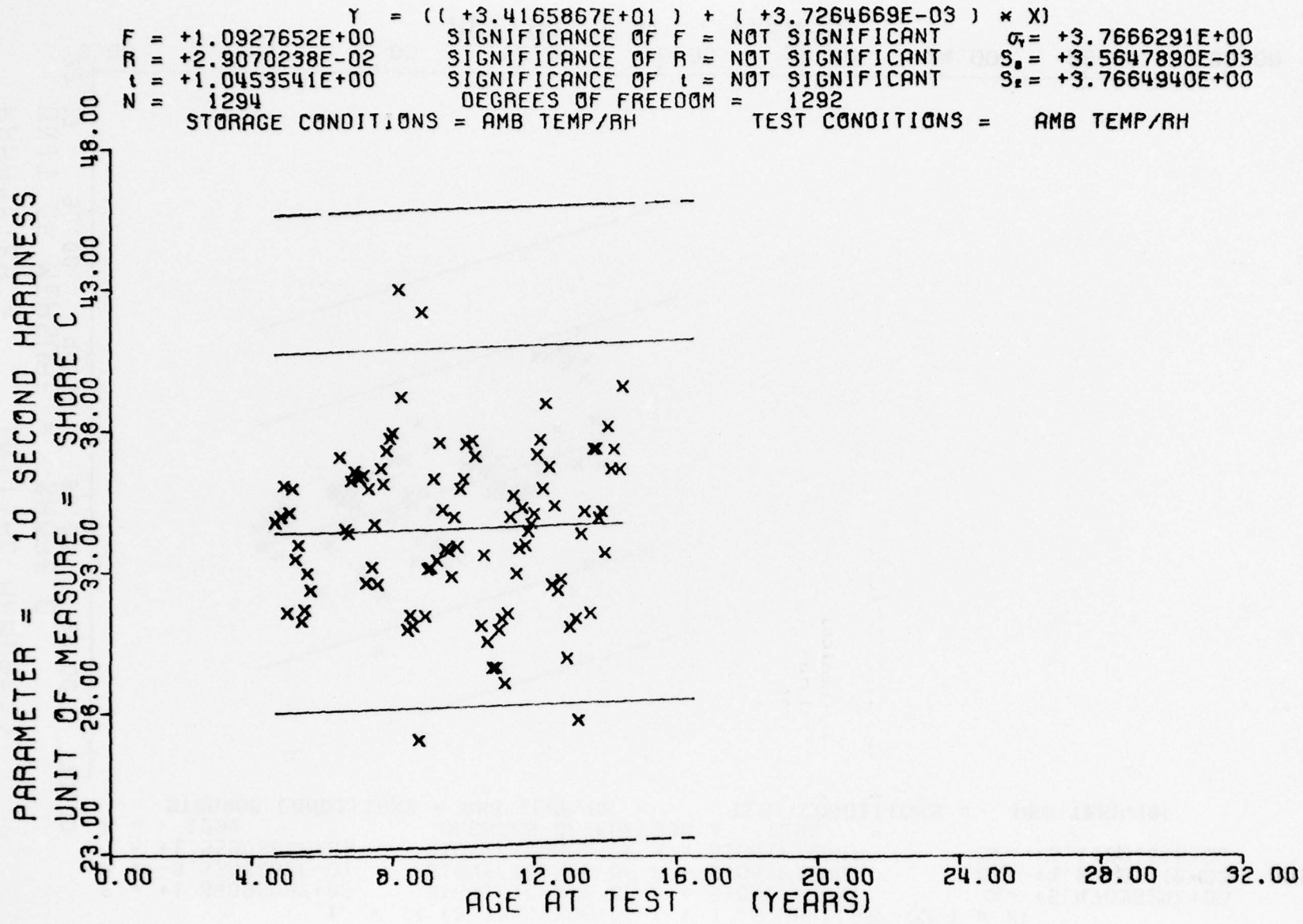
Y = ((+3.4165867E+01) + (+3.7264669E-03) * X)
F = +1.0927652E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σy = +3.7666291E+00
R = +2.9070238E-02 SIGNIFICANCE OF R = NOT SIGNIFICANT Sb = +3.5647890E-03
t = +1.0453541E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT Sε = +3.7664940E+00
N = 1294 DEGREES OF FREEDOM = 1292
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = 10 SECOND HARDNESS
UNIT OF MEASURE = SHORE C
48.00
43.00
38.00
33.00
28.00
23.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
WING 246 HARDNESS SHORE C 10 SECOND TP-H1043 PROPELLANT

Figure 14

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Solid Propellant
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Aft Closure

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report contains propellant test results from cartons of TP-H1043 propellant representing selected batches used in the aft closure of First Stage-Minuteman Motors. Data from TP-H1043 propellant obtained from the aft closures of the LGM-30A, B, F and G Motors are reported in regression analyses for the fourth time and the third time using the GO-85 computer system. Testing was accomplished in accordance with MMWRME Projects M82937C and M82938C.

An analysis of all parameters indicate that no significant degradation is

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anticipated for at least two years past the oldest data point.

Each point on the regression plot represents all samples at that particular age. The number of samples at each point is indicated on the sample size summary sheet on the page accompanying each regression plot. The data range at any age can be found by suitable inquiry of the GO-85 system.